Example 1

1. *According to the HITRAN database the ozone line at 1020.3189* cm^{-1} *has an air broadened halfwidth of .0706* cm^{-1} *at 1 atm (*$p_0 = 1013.25$ *mb) and* $T_0 = 296$ *K and a temperature coefficient of* $n = .76$.

Calculate the absorption coefficient and optical depth of this layer

We would like to compute the optical depth at a wavenumber of 1020.319 cm^{-1} *for a 1 km thick layer at a pressure of* $p = 102$ *mb and temperature of* $T = 217$ *K. The volume mixing ratios of the ozone is* $q_{O3} = 2.22 \times 10^{-6}$.

The number of air molecules per cm^2 *in this layer is*

$$u_{air} = \frac{\Delta z N_A p}{R^* T} = 3.40 \times 10^{23} \text{ molec/cm}^2$$

Since we are considering a single Lorentz absorption line, we use the Lorentz line shape f. The the absorption coefficient is given by

$$k_\nu = Sf(\nu - \nu_0) = \frac{S\alpha/\pi}{(\nu - \nu_0)^2 + \alpha^2}$$

The halfwidth of the Lorentz line shape scales according to

$$\alpha = \alpha_0 \left(\frac{p}{p_0}\right)\left(\frac{T_0}{T}\right)^n$$

Thus, α=0.009, and from HITRAN data base S=1.890x 10^{-20} cm/molec.

For the desired wave-number of ν=1020.319 cm-1 the monochromatic absorption coefficient is

$$K_\nu = \frac{\left(1.890\times10^{-20}\ cm/molec\right)\left(0.0048cm^{-1}\right)/\pi}{\left(1020.3190cm^{-1} - 1020.3189cm^{-1}\right)^2 + \left(0.0090cm^{-1}\right)^2} = 3.6\times10^{-19}\ cm^2/molec$$

The optical depth of the layer at this wavenumber is the absorber amount of CO_2 times the absorption coefficient

$$\tau = k_\nu u_{O3} = k_\nu q_{o3} u_{air}$$

$$\tau = \left(3.6\times10^{-19}\ cm^2/molec\right)\left(2.22\times10^{-6}\right)\left(3.40\times10^{23}\ molec/cm^2\right) = 0.27$$